Safety Flares Threaten Water Quality with Perchlorate

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INTRODUCTION:

Results from a series of common highway safety flare tests conducted by the Santa Clara Valley Water (District) confirm that flares can be a significant source of perchlorate (ClO_4-) contamination to water, even when the flares are 100% burnt. Up to 3,645,000 μg (243,000 μg/L) of perchlorate ions leached out of a single standard 20-minute unburned flare in just 3.5 hrs of contact with 15 L of clean water. Fully burned flares leached up to 1,950 μg of perchlorate ions per flare.

Theoretically (assuming 100% homogenous full mixture and 0% mass losses), a single unburned 20-minute flare can potentially contaminate up to 2.2 acre-feet of drinking water to just above California Department of Health Services' current Action Level of 4 μg/L. More than 40 metric tons of flares were used/burned in 2002 alone in Santa Clara County.

The pilot tests monitored flare-water mixtures for pH, conductivity, temperature, and dissolved concentrations of perchlorate and nitrate (as NO_3-), including dry weight analysis. Report with details will be posted at: http://www.valleywater.org/Water/Water_Quality/Protecting_your_water/_Lustop/Perchlorate.shtm

Figure 1 – Unused standard safety/road flares/fusee

Table 1 – Test Series No. 1

Test No.	Flare Description[1]	Simulation
M1	0% burnt + sliced open	Represents conditions of unburned, followed by partial destruction (run over by motor vehicles) flare in contact with rainfall.
M2	50% burnt + unaltered	Represents conditions of 50% flare burnt during dry conditions, experiencing no other damage (in contrast to M3), followed by rainfall.
M3	50% burnt + sliced open	Represents conditions of 50% flare burn during dry conditions, followed by run over by motor vehicles, then rain fall.
M4	100% burnt + sliced open	Represents conditions of 100% flare bunt during dry conditions, followed by partial destruction/run-over by vehicles, followed by rainfall.
M5	control blank (no flare)	Represents clean water having no contact with flares intended to quantify experimental error resulting from cross-contamination.

Table 2 – Test Series No. 2

Test No.	Flare Description[1]	Simulation
M6	100% burnt + sliced open	Represents conditions of 100% flare bunt during dry conditions, followed by partial destruction/run-over by vehicles, followed by rainfall. This is comparable to M4.
M7	90% burnt + sliced open	Represents conditions of 90% (18 minutes) flare burnt during dry conditions, experiencing being run over by vehicles, followed by rainfall.
M8	67% burnt + sliced open	Represents conditions of 67% (13.5 minutes) flare burnt during dry conditions, experiencing being run over by vehicles, followed by rainfall.
M9	0% burnt + NO WATER (Solids Analysis)	Represents flare (20-minute) for solids analysis of perchlorate and nitrate without any submergence/dilution with water.
M10	Control blank	Represents clean water having no contact with flares intended to quantify experimental error resulting from cross-contamination. This compares to M5.
M11	Triple blind blank	Independent laboratory spiked perchlorate sample. ID No. 0204-03-03.1

[1] All flares (20-minute) were burnt in dry environments and therefore do not account for significant mass losses to the atmosphere that would likely not occur during the burning of a flare during a rain fall event.

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RESULTS:

Table 3 – Results Summary

Test Series	Test No.	°C	E.C. (mS/cm)	pH	Perchlorate (µg/L)	Nitrate (mg/L)
Series No. 1 (3.5 hrs)	M1 (0% burned & sliced)	19.0	5	8.7	243,000	5,920
	M2 (50% burned & unaltered)	19.6	1.7	11.9	7,800	94.3
	M3 (50% burned & sliced)	19.1	4.0	11.8	151,000	3,250
	M4 (100% burned & sliced)	19.2	2.8	12.3	103	12
	M5 (control blank – no flare)	18.6	0.004	8.6	48	<2
Series No. 2 (24 hrs.)	M6 (100% burned & sliced)	16.0	4.1	12.4	130	14
	M7 (90% burned & sliced)	15.6	4.6	12.3	6,300	-
	M8 (67% burned & sliced)	14.8	5.9	12.1	160,000	-
	M9 (0% burned & no water; solids analysis)	-	-	-	50,000,000 (µg/Kg)	450,000 (mg/Kg)
	M10 (control blank)	15.1	0.003	6.9	<4	-
	M11 (triple blind blank)	-		-	7.5	-

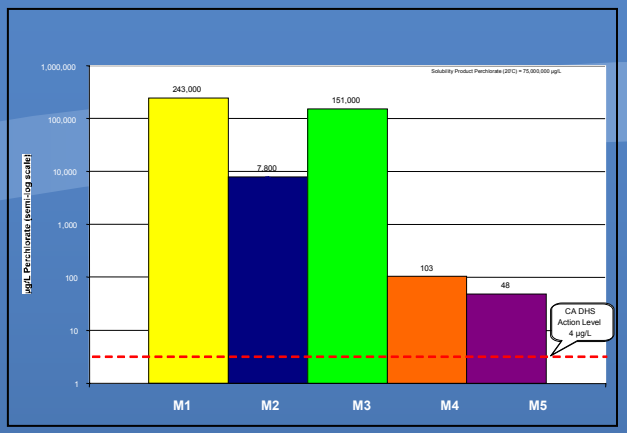

Figure 3 – Test Series No. 1 - Perchlorate Leached

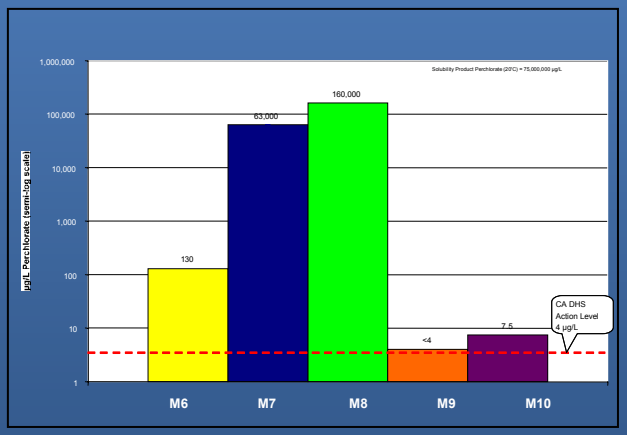

Figure 4 – Test Series No. 2 - Perchlorate Leached

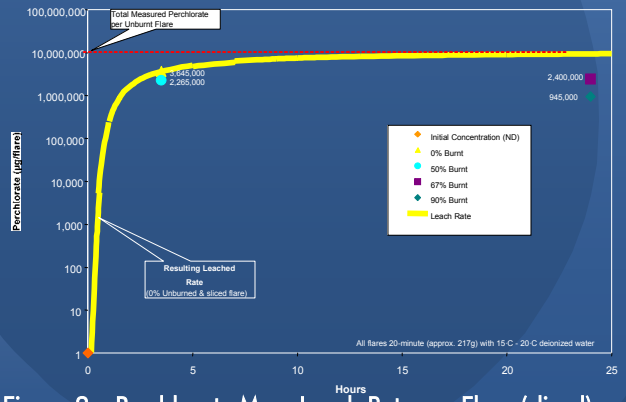

Figure 2 – Perchlorate Mass Leach Rate per Flare (sliced)

CONCLUSIONS:

(1) Flares can be a significant source of perchlorate contamination to both surface and groundwater.

(2) Unburned flares improperly disposed of can contaminate water with perchlorate up to 2,000 times more than 100% burnt flares.

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Santa Clara Valley Water District